2004 NASA CELL SCIENCE CONFERENCE

From Cells to Operations:

Opportunities to Integrate Space Biomedical Research

Jeffrey P. Sutton, M.D., Ph.D., ***Director***

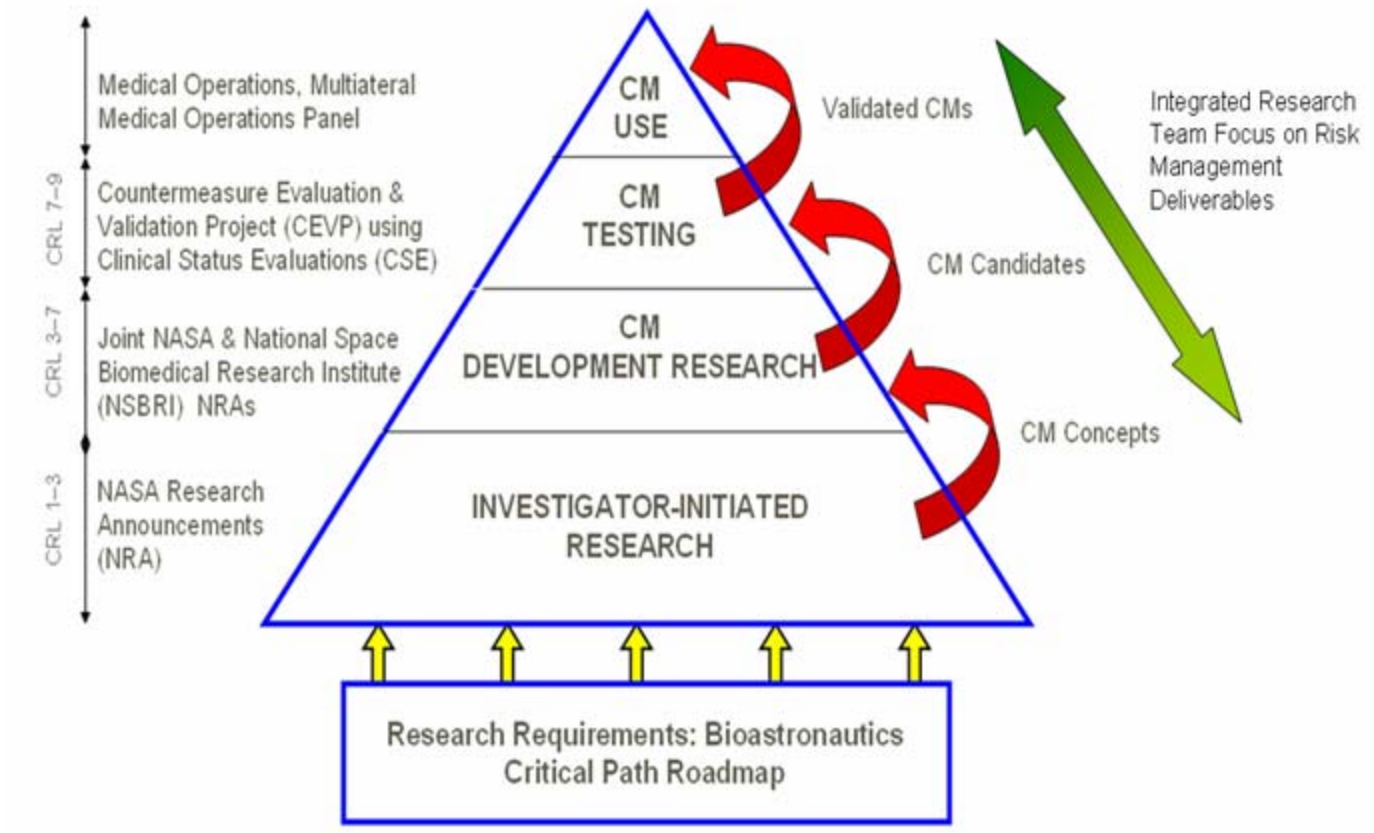
National Space Biomedical Research Institute

February 26, 2004

Introduction

- Non-profit organization forming a unique partnership between the academic biomedical community and NASA
- **Mission:** To conduct biomedical research to define adverse medical and biological consequences associated with space travel and to identify approaches or countermeasures to prevent, minimize and reverse those adverse processes
- Selected by NASA in 1997 following an open national competition
- Goal-driven peer-reviewed research conducted by multi-disciplinary, integrated teams composed of outstanding scientists geographically dispersed across the nation

Integrated Team Approach to Solving Critical Questions on the BCPR



- **Key links that bridge the scientific/clinical expertise and resources of the biomedical community with the scientific/engineering and operational expertise of NASA**

Current NSBRI Program

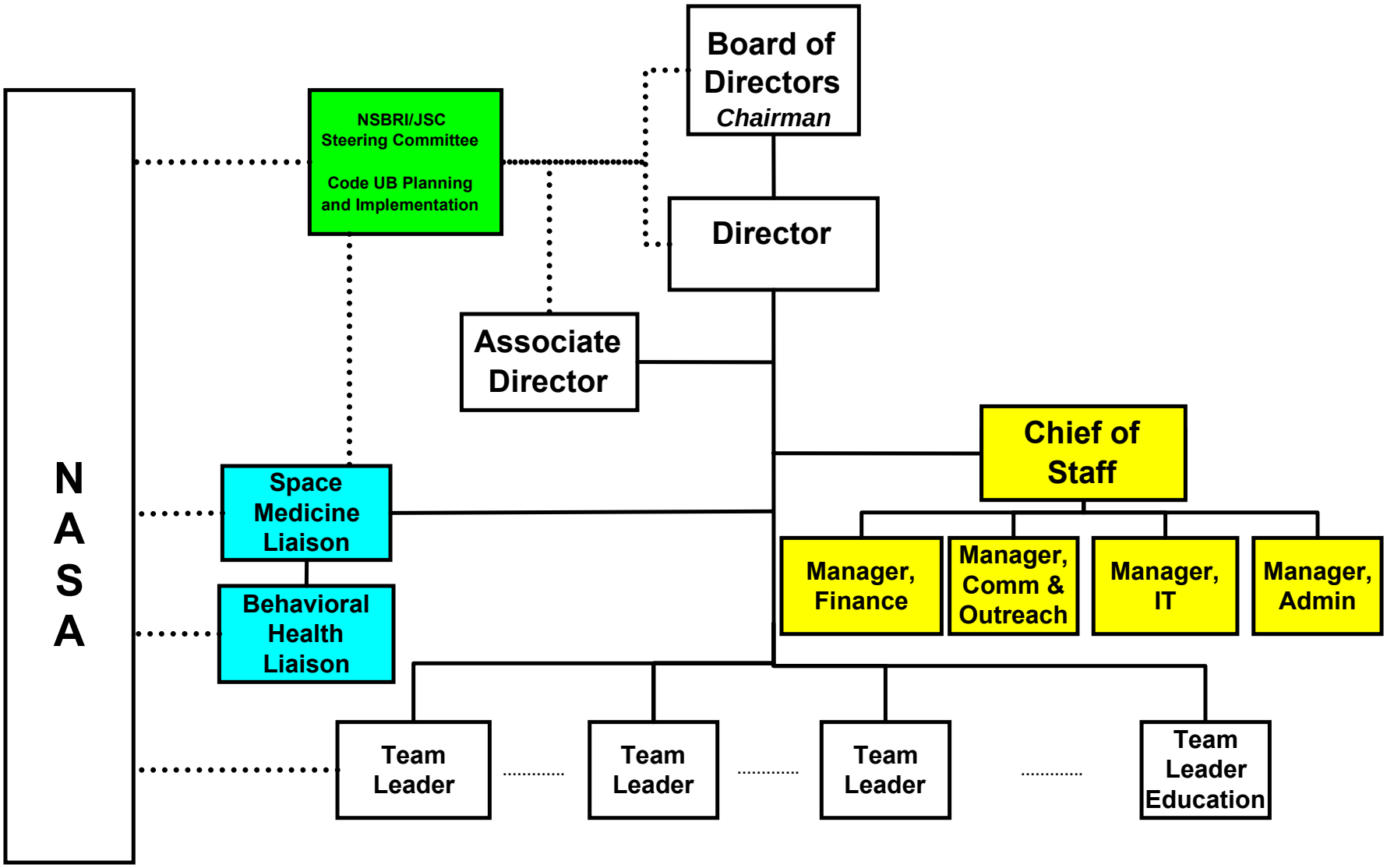
Research Teams	12
Research Projects	
Ground	91
Flight	2
Space Medicine	2
Education / Outreach Projects	7
Investigators	280
Institutions	81
States	22

Organization and Management

- Institute Strategic Plan (2003, www.nsbri.org)
- Incorporation of Team Strategic Plans for research and education/outreach
- Alignment with Bioastronautics Critical Path Roadmap, Bioastronautics and OBPR Strategies

- Partnership with NASA: Cooperative Agreement (5 yr increments), Cooperative Agreement Management Plan, NSBRI/NASA Steering Committee
- Corporate Structure: Board of Directors, Board of Scientific Counselors, Team Leaders, External Advisory Council, Industry Forum, User Panel, International Partners, …

Organizational Structure



Select Research Teams and Leads

Bone Loss	**P Cavanagh, Ph.D. (Cleveland Clinic)**
Cardiovascular Alterations	**R Cohen, M.D., Ph.D. (MIT)**
Human Performance	**C Czeisler, Ph.D., M.D. (Harvard)**
Immunology, Infection and Hematology	**Ann Kennedy, D.Sc. (Penn)**
Muscle Alterations and Atrophy	**K Baldwin, Ph.D. (UCI)**
Neurobehavioral and Psychosocial Factors	**D Dinges, Ph.D. (Penn)**
Nutrition, Physical Fitness and Rehabilitation	**J Lupton, Ph.D. (Texas A&M)**
Neurovestibular Adaptation	**C Oman, Ph.D. (MIT)**
Radiation Effects	**J Dicello, Ph.D. (Johns Hopkins)**
Smart Medical Systems	**L Crum, Ph.D. (U Washington)**
Technology Development	**J Buckey, M.D. (Dartmouth)**

Progress and Productivity

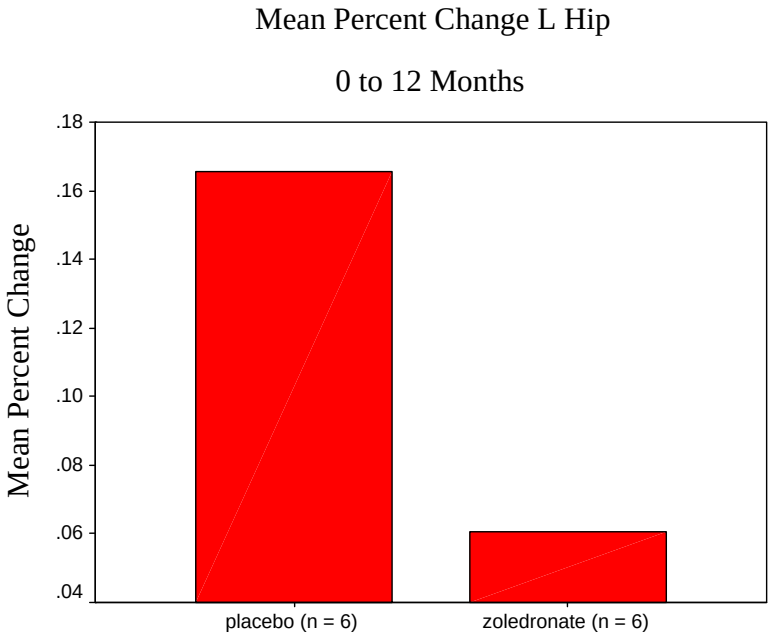
- **Annual Scientific and Technical Report**
  - **Peer-reviewed articles**
  - **Invention disclosures/patents**
  - **Countermeasure Development Pipeline**
  - **Deliverables - TOFMS, zoledronate, …**
  - **Earth based spin-offs**
  - **Education program**

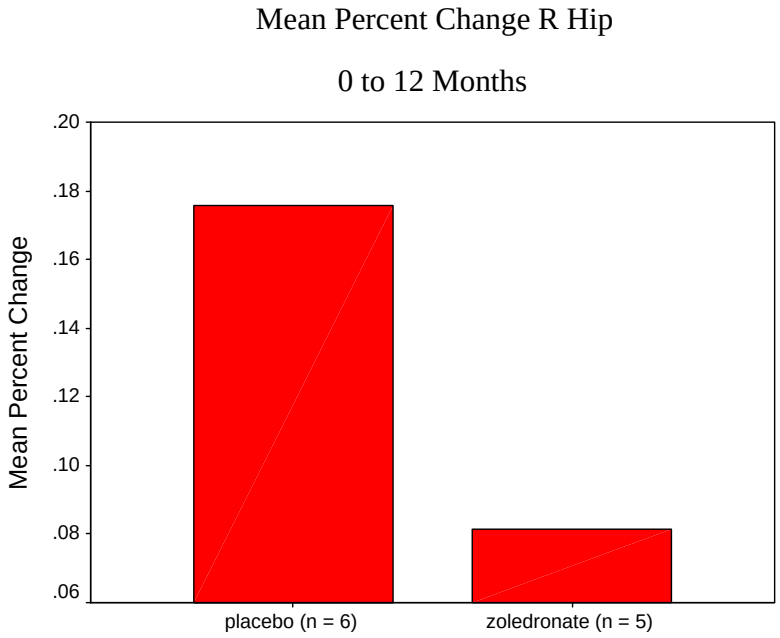
- **<u>Integration</u> between NSBRI and NASA biomedical research and countermeasure (BR&C) development (and AHST) projects, and other NASA programs/centers**

- **<u>Integration</u> between research and space medicine, for operationally relevant countermeasure development (e.g., support of hypothesis-driven research ↔ CSE ↔ autonomous medical care continuum)**

Selected Research Achievements

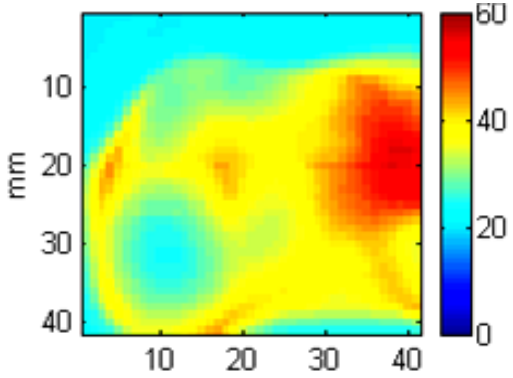
- **Demonstrated significant effect in spinal cord injury patients of IV zoledronate on reducing total hip bone mineral density after one year of observation following a single infusion of drug (Dr. Jay Shapiro, USUHS, Novartis)**

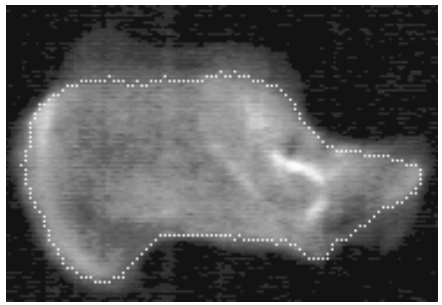




Selected Research Achievements

- **Development of a novel portable confocal acoustic imaging device to assess bone mineral density *and* strength in real-time in the space environment. Earth applications include the use of the device to monitor treatment for osteoporosis, which is estimated to affect 10 million individuals (Dr. Yi-Xian Qin, State University of New York–Stony Brook)**



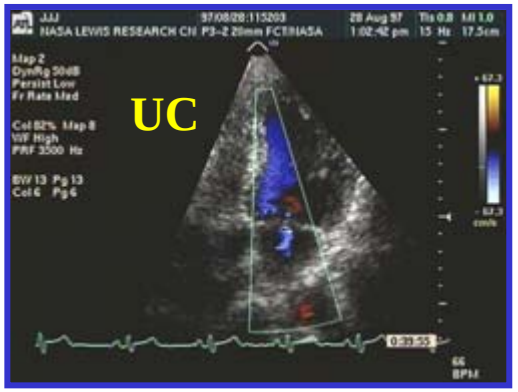


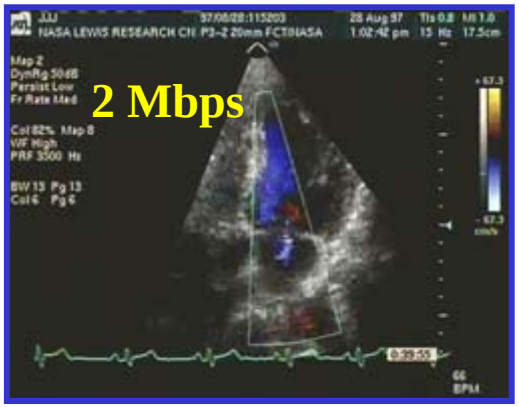
DXA

- **Development of a portable AMPDXA Advanced, Dual Energy X-ray Absorptiometry (AMPDXA) Scanning System (Dr. Harry Charles, featured in *Advancing Microelectronics)***

Portable Acoustic Imaging

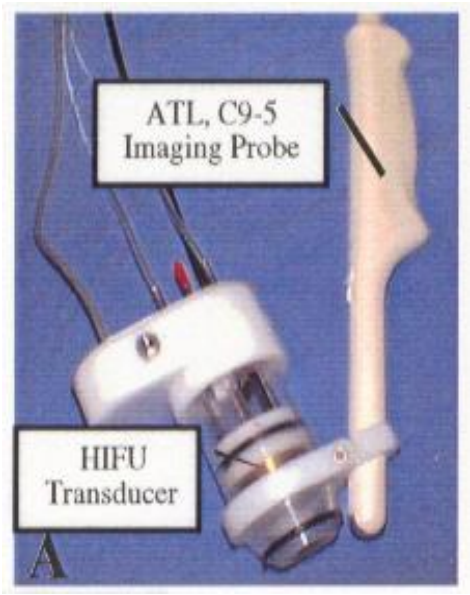
SonoSite™ Hand Carried Ultrasound

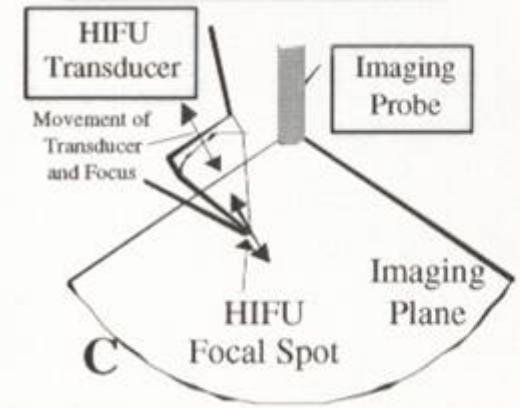


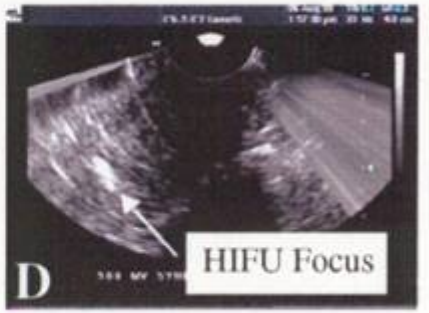


3D ultrasonography with real-time interpretation

Non-invasive Diagnostic and Therapeutic Platforms

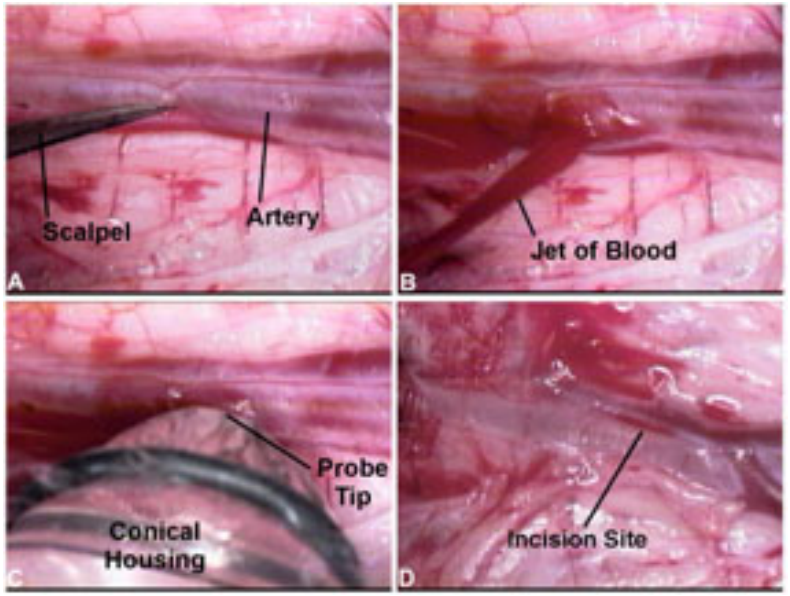






High-Intensity Focused Ultrasound (HIFU) System

Time derivative automated assessment and image guided therapy



Selected Research Achievements

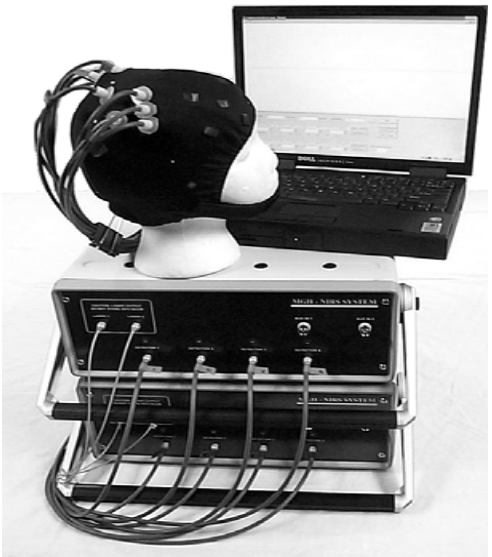
- Demonstration that there is less ability to clear infection, with increased mortality, in a microgravity model of animals exposed to proton and gamma radiation. The effects of radiation on immunity speak to possible replacement of gamma globulin as a protective countermeasure (Dr. Janet Butel, Baylor College of Medicine, *Lancet*)
- Discovery of Atrogin-1, a muscle-specific protein highly expressed during muscle atrophy that is not only relevant for microgravity adaptation but also for molecular therapeutic approaches to combat muscle atrophy associated with diverse diseases (Dr. Alfred Goldberg, Harvard Medical School, *Proceedings of the National Academy of Science* and *Nature Medicine*)
- The role of nutrition in space was highlighted in a special issue of *Nutrition*, which involved 23 investigators throughout the NSBRI/NASA community

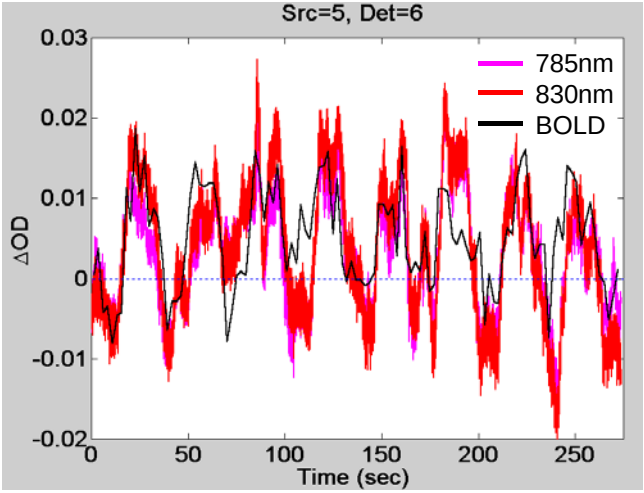
Selected Research Achievements

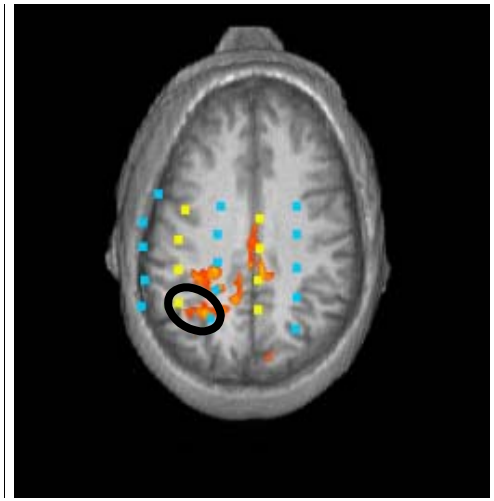
- **Identification in an Antarctic analog study that female leaders consistently feel more isolated than male leaders. Countermeasure development is providing details on the roles various relationships play, how groups react in relation to gender and what factors in crew selection are important for long-duration space missions (Dr. JoAnna Wood, Baylor College of Medicine, NASA JSC)**

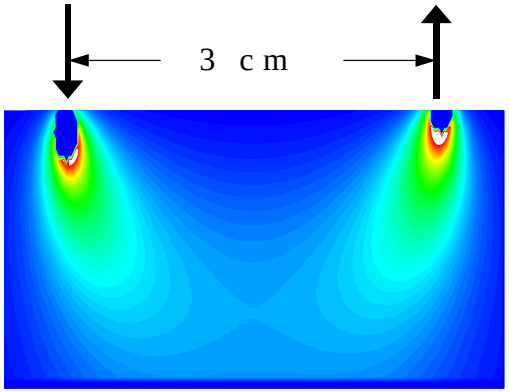
- **Use of interview data from astronauts and cosmonauts who participated in long-duration missions to develop a computer-based system for self-diagnosis and treatment of psychosocial problems (Drs. James Carter and Jay Buckey, Jr., Harvard Medical School and Dartmouth Medical School, *Journal of American Medical Association)***

Diffuse Optical Tomography







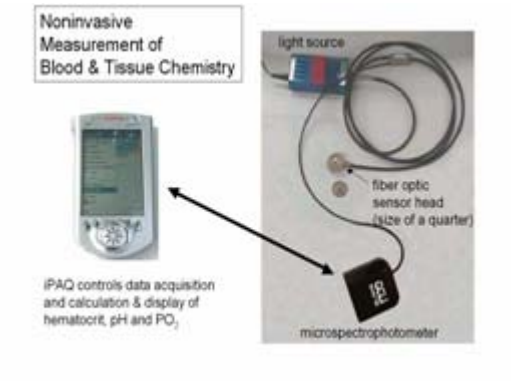


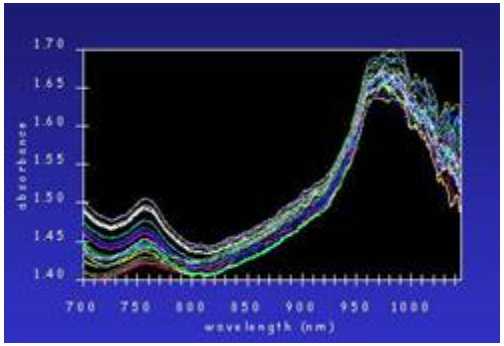
Non-invasive assessment of brain function under cognitive load and sleep disturbance to adjust performance expectations (e.g., docking)

Adaptation, neuromonitoring

Selected Research Achievements

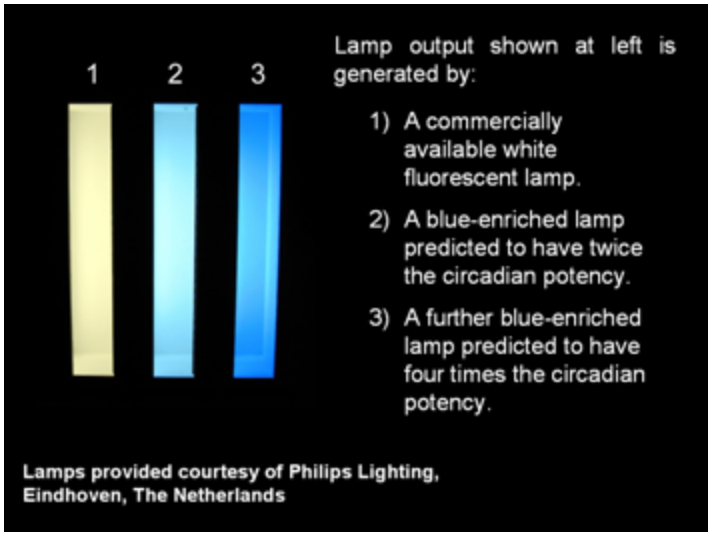
- **Development of lightweight, low power, portable near infrared sensors and algorithms to non-invasively determine blood and tissue chemistry, including applications to assess muscle pH in real time to optimize exercise countermeasures. Earth-based applications include the ability to non-invasively detect reduced peripheral perfusion in diabetes, a condition affecting 17 million Americans. (Dr. Babs Soller, University of Massachusetts Medical School)**



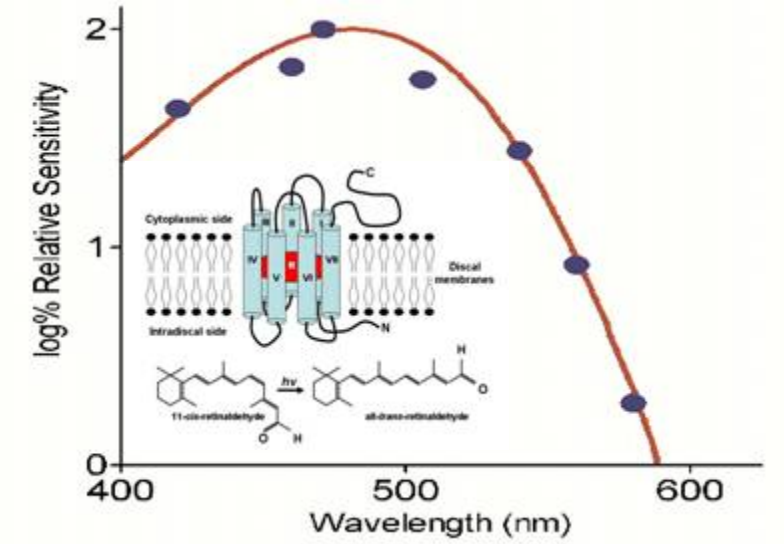


Selected Research Achievements

- **Progress to optimize the light spectrum, especially at 420-460 nm, to enhance human performance (Dr. George Brainard, Jefferson Medical College, Philips)**



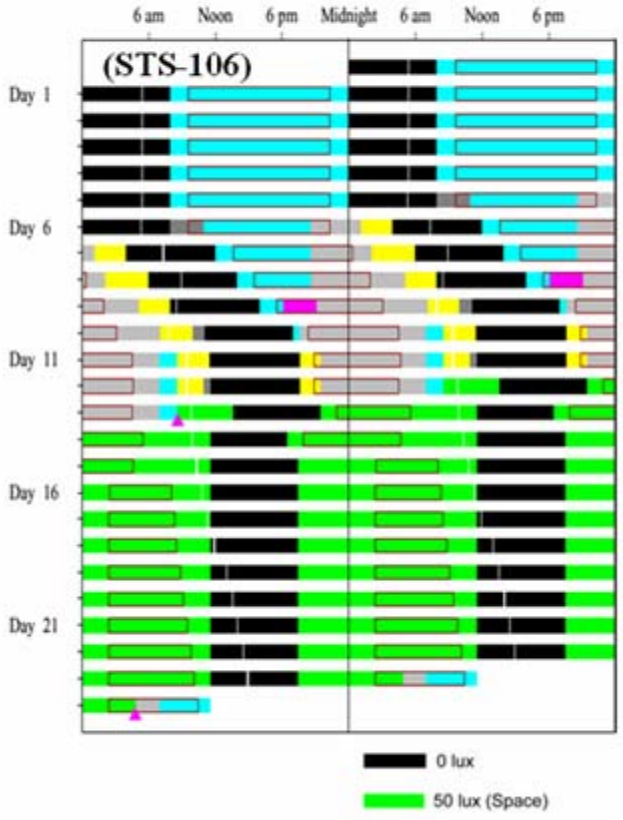
- **Identification of a novel opsin in the mouse rod-cone photoreceptor system, with λmax ~ 480 nm (Dr. Russell Foster, Imperial College, *Nature*)**



Selected Research Achievements

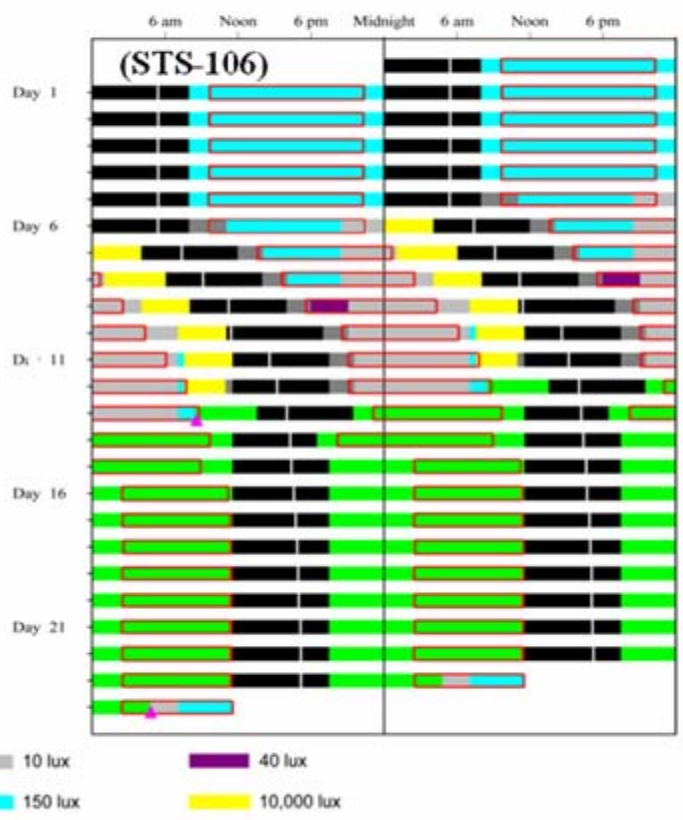
1) Evaluate Actual Schedule

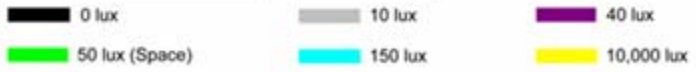
Note less than optimal performance predicted during launch, landing and much of wakefulness in space



2) Determine Optimal Schedule

Solution: Removing morning bright light exposure & increase evening bright light duration





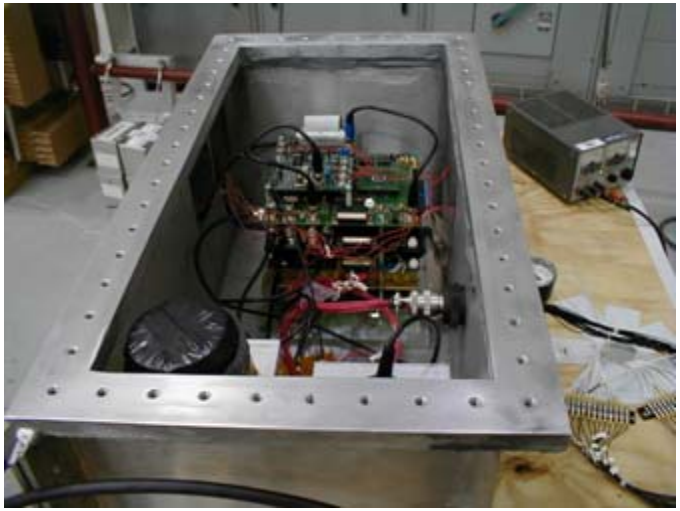
Circadian Performance Simulation Software (CPSS) package - M Jewett, Ph.D. (PI, Harvard)

Selected Research Achievements

- **Development and testing of a miniature time-of-flight mass spectrometer, with great potential for onboard analysis of chemical and biological substances, with scientific, medical and environmental applications for space and homeland security (Dr. Richard Potember, Johns Hopkins)**

Selected Research Achievements

- Development and testing of a neutron energy spectrometer revealing downward neutron energy spectrum at 86,000 ft altitude above Earth, with applications for multiple design reference missions for human space travel (Dr. Richard Mauer, Johns Hopkins)



Flight instrument

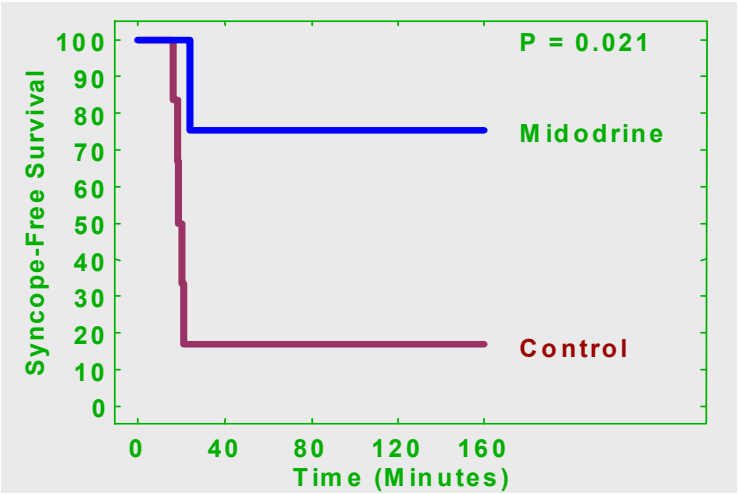
Qualification testing

NASA/NSBRI Medical Operational Support Team

- Space-adapted human patient simulator project that brings together the NSBRI's clinical and science expertise to work with NASA medical operations personnel to simulate medical events and countermeasure efficacy
- PI: Dr. Hal Doerr, Baylor College of Medicine
- Relevance to space medicine, medical operations, training

Selected Research Achievements

- **Ground-based studies and successful transition to flight studies of midodrine as a means to combat post-flight orthostatic hypotension. Mechanisms are being investigated that underlie the observation that nearly all females, while only 50% of males, are tilt intolerant following simulated microgravity (Dr. Richard Cohen of Massachusetts Institute of Technology, Dr. Janice Meck of JSC)**



Conclusions

- **NSBRI is maturing and making adjustments to ensure that it meets its mission with NASA**
- **Clear added value to NASA's BR&C program**
- **Operating in accord with the President's Management Agenda**
- **Opportunities which bridge fundamental biology and translational research towards operations**
- **Innovation and directed research which engage an open community to conduct highly meritorious projects toward deliverables (e.g., knowledge, devices, systems) are paramount**

For further information, contact

Jeffrey Sutton, M.D., Ph.D., *Director*

Jeanne Becker, Ph.D., *Associate Director and Chief Scientist*